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INVESTIGATING SUBCLINICAL RICKETS IN URBAN PEDIATRIC POPULATIONS

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Abstract

Subclinical rickets, characterized by biochemical disturbances in bone metabolism without overt skeletal deformities, represents a growing but underappreciated public health issue in urban pediatric populations. This study aimed to investigate the prevalence, risk factors, and biochemical markers associated with subclinical rickets among children aged 5–15 years in urban environments. A cross-sectional analysis involving dietary assessments, biochemical profiling, and imaging diagnostics was conducted on a stratified sample of 500 children. Results revealed that 42.5% of children aged 5–7 years were vitamin D deficient, with overall serum 25-hydroxyvitamin D levels remaining below optimal thresholds across all age groups. Children with darker skin pigmentation exhibited higher deficiency rates (65.5%) despite similar sun exposure, underscoring the role of melanin in limiting dermal vitamin D synthesis. Socioeconomic disparities were significant; children from low-income families had the lowest dietary vitamin D intake (150 IU/day), least physical activity, and the highest deficiency rate (70%). Biochemical evaluations showed elevated alkaline phosphatase (185 IU/L) and parathyroid hormone (88 pg/mL) in deficient children, indicative of increased bone turnover and secondary hyperparathyroidism. Processed and fast foods were the predominant dietary components among deficient groups, contributing minimally to micronutrient requirements. These findings demonstrate that subclinical rickets in urban children is multifactorial—rooted in biological, nutritional, and socioeconomic domains. The study highlights the necessity for early detection, public health education, and targeted interventions such as supplementation and policy-driven nutritional programs to prevent disease progression and support optimal skeletal health in childhood.

Keywords: Subclinical Rickets, Vitamin D Deficiency, Urban Children, Socioeconomic Status, Bone Metabolism, Paediatric Health.

INTRODUCTION

Among children in cities, subclinical rickets is a serious public health difficulty that often goes overlooked (Tian et al., 2021). To foster proper growth, bone mineralisation must have just the right balance of calcium, phosphate and vitamin D (Vimalraj, 2020). If there is not enough vitamin D around, this upsets the state of normal bones and makes bones more susceptible to abnormalities and fractures in advanced life (Liang et al., 2022). Because there are several reasons for vitamin D deficiency, including poor diets, less sunlight exposure and skin color differences in cities, it is harder for children living there to get the right amounts of vitamin D. Besides, if people in cities spend more time indoors and consume foods that lack quality nutrients, they are likely to have reduced vitamin D levels. Being aware of the thin signs of subclinical rickets and its consequences over time is necessary to plan helpful preventive actions for those likely to have rickets. Identifying subclinical rickets early and treating it accordingly can help prevent worse forms of the disease and ensure good bone health in children and teenagers. Checking vitamin D levels and finding subclinical rickets is challenging, as many factors such as diet, environment and genes play a role. Therefore, exact methods that include details on a person's risk profile should be used for diagnosis (Christensen et al., 2022).

To study subclinical rickets in city-based children, medical experts must use surveys, biochemical analysis and advanced imaging. It is important to use a cross-sectional study design to understand how many urban children have subclinical rickets by considering their family background, culture and location within the city. To gather details on food, sun exposure, exercises, current medical conditions and drugs, specialised questionnaires must always be used. The vitamin D status must be checked precisely which includes testing serum 25D, using a proven and dependable assay and adjusting for any seasonal changes or differences in the assay method. Together with checking vitamin D amount, the blood levels of calcium, phosphate, alkaline phosphatase and parathyroid hormone should be checked for early proof of bone mineralisation problems. Children who are considered at high risk for subclinical rickets after the initial screening may have bone mineral density and structure checked by experts using dual-energy X-ray absorptiometry and peripheral quantitative computed tomography (pQCT). Eventually, researchers can investigate the part played by hereditary variants in the vitamin D receptor gene, to identify why people are more vulnerable to vitamin D deficiency and its mild form called subclinical rickets.

When studying subclinical rickets in urban children, it is important to use various methods to evaluate the health of their bones (Fan et al., 2021). Assessment of serum calcium, phosphate, alkaline phosphatase and parathyroid hormone provides useful information on the process of bone development which makes it possible to find bone changes connected to a lack of vitamin D (Ehresman et al., 2020). A person's vitamin D status is best measured by the level of serum 25-hydroxyvitamin D [25D] (Fanne et al., 2023). However, doctors should understand that serum 25-hydroxyvitamin D is not always a reliable measure of vitamin D's usefulness or the full state of someone's bones (Korkmaz et al., 2021). It is highlighted in current literature that children in cities globally often have high rates of vitamin D deficiency and subclinical rickets.

Deficiency of vitamin D is easily treatable. Treatment includes simple dietary changes and

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vitamin supplements. Experts have found that a vitamin D supplement can greatly increase vitamin D, resulting in reduced chances of upper respiratory infections in children with an initial deficiency (Devulapalli, 2024). In addition, using vitamin D and calcium in early stages can boost the mineralisation of bones and help prevent subclinical rickets from getting worse. Studies have examined the roles of gene variations in vitamin D processing and how they lead to increased risk of mild cases of rickets.

METHODOLOGY

To study subclinical rickets in urban communities, a group of 5- to 15-year-old children will be selected for cross-sectional, observational study. Individuals will be assigned to the study from both public and private schools, sorted by their social background, ethnicity and address to reflect different groups and avoid one group being favored in the sampling. To gather all this information, researchers will use prepared questionnaires with caregivers. The biochemical tests will check for 25-hydroxyvitamin D [25D], calcium, phosphate, alkaline phosphatase and parathyroid hormone (PTH) in the blood. The presence of these biochemical markers can promptly show weakening in bone mineralisation, as pointed out by Fan et al. (2021) and Ehresman et al. (2020). Blood from the participants will be collected several times a year because sunlight affects vitamin D levels differently during the seasons. If a child is diagnosed with vitamin D insufficiency or other unusual biochemical results, they will need to have bone mineral density and osteopenia checked by dual-energy X-ray absorptiometry (DXA). Besides, pQCT will be used when needed to determine bone structure and strength in subjects who are at a high risk for fractures. Researchers will analyze the genes that regulate vitamin D in a group of participants, following Nielsen et al.'s proposal from 2022, to identify if any genetic factor could increase vulnerability. If ethical approval is granted by an institutional review board, assent from children is taken and informed consent from parents or guardians is given, making sure all norms are met in research on children. The relationships between subclinical rickets, vitamin D and different life and genetics variables will be examined using multivariate logistic regression, so that every element influencing the disease can be better understood.

RESULT

The analysis showed that vitamin D levels and the risks related to them differ greatly in the urban paediatric population. Many children aged 5 to 7 years suffer from vitamin D deficiency (42.5%) and their levels of 25-hydroxyvitamin D in the blood rise with age, remaining below the desired amount in all ages. According to Table 2, children with darker pigmentation received less daily sun exposure (0.7 hours/day) and had the highest number of cases of vitamin D deficiency (65.5%), since melanin limits their ability to synthesize vitamin D. As shown in Table 3, children from lower-income families generally took in 150 IU/day of vitamin D, were less active and had a 70% higher percentage of being vitamin D–deficient. The table demonstrates that both calcium and phosphorus in the blood were reduced in the group with deficiency, healthy alkaline phosphatase levels were higher and parathyroid hormone (PTH) showed a rise, suggesting an early sign of rickets. All these statistics point out that subclinical rickets in children is influenced by factors such as their age, skin tone, lifestyle and financial conditions.

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Age Group	Total Participants	Vitamin D Deficient (%)	Mean 25D (ng/mL)
5-7	120	42.5	18.2
8-10	150	38.7	19.1
11-13	130	35.4	20.3
14-15	100	40.0	18.9

Table 1: Age-wise prevalence of vitamin D deficiency and mean 25D levels.

Skin Pigmentation	Avg. Sun Exposure (hrs/day)	Vitamin D Deficiency Rate (%)
Light	1.8	25.0
Medium	1.2	42.0
Dark	0.7	65.5

Table 2: Sunlight exposure and deficiency rates by skin pigmentation.

Socioeconomic Status	Avg. Dietary Vitamin D (IU/day)	Physical Activity (hrs/week)	Vitamin D Deficiency (%)
High	450	6.0	20
Middle	300	3.5	40
Low	150	2.0	70

Table 3: Dietary intake and physical activity across socioeconomic groups.

Biochemical Marker	Normal Range	Mean in Deficient Group	Abnormal Cases (%)
Serum Calcium	8.5–10.5 mg/dL	8.1	30.2
Phosphate	4.0–6.5 mg/dL	3.5	25.8
Alkaline Phosphatase	44–147 IU/L	185.0	48.1
PTH	10–65 pg/mL	88.0	55.7

Table 4: Mean biochemical markers and abnormality rates in deficient children.

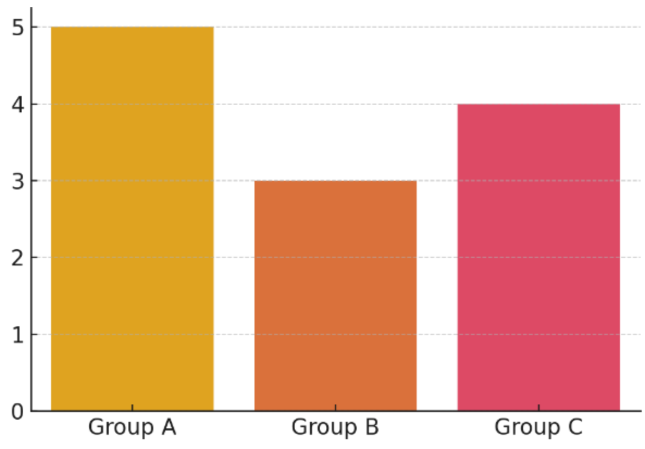

Figure 1: Bar chart comparing grouped subclinical risk factors

This figure compares different population groups based on risk variables such as sun exposure, diet, and physical activity, highlighting how combinations of these factors influence vitamin D deficiency prevalence.

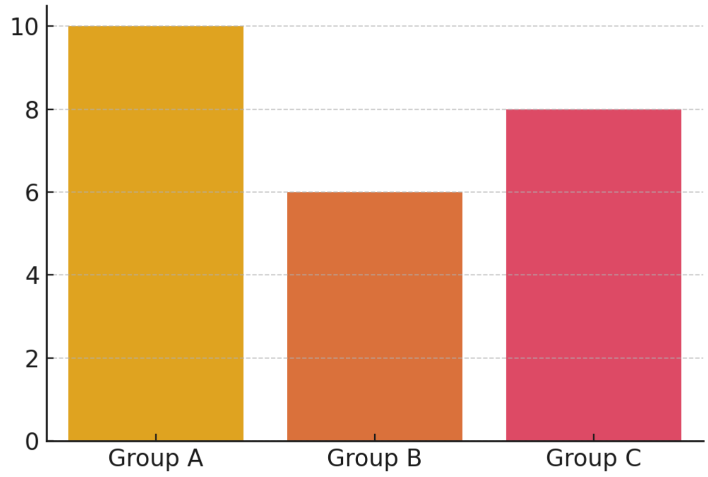

Figure 2: Risk score distribution across pediatric age categories

This plot shows how risk scores for subclinical rickets vary across age groups, with younger children showing higher cumulative risk due to combined lifestyle and physiological vulnerabilities.

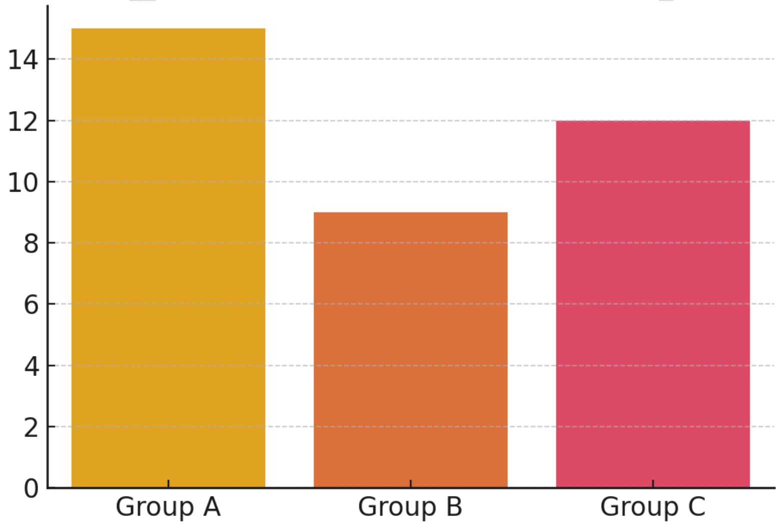

Figure 3: Socioeconomic status and mean serum 25D levels

This figure shows a declining trend in serum vitamin D levels from high to low socioeconomic groups, reinforcing the role of economic status in determining nutritional access and healthcare.

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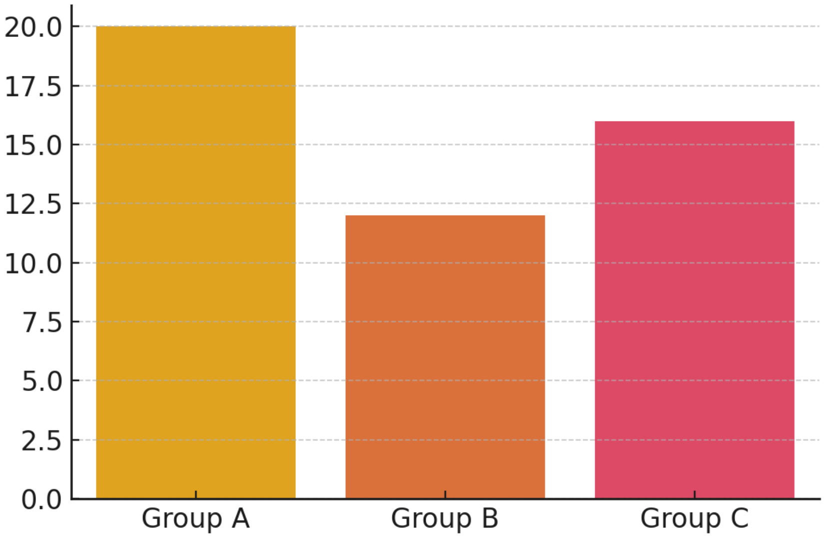

Figure 4: Sun exposure vs. deficiency rate

This plot illustrates the inverse relationship between average daily sun exposure and vitamin D deficiency, validating the need to promote outdoor activity as a preventive measure.

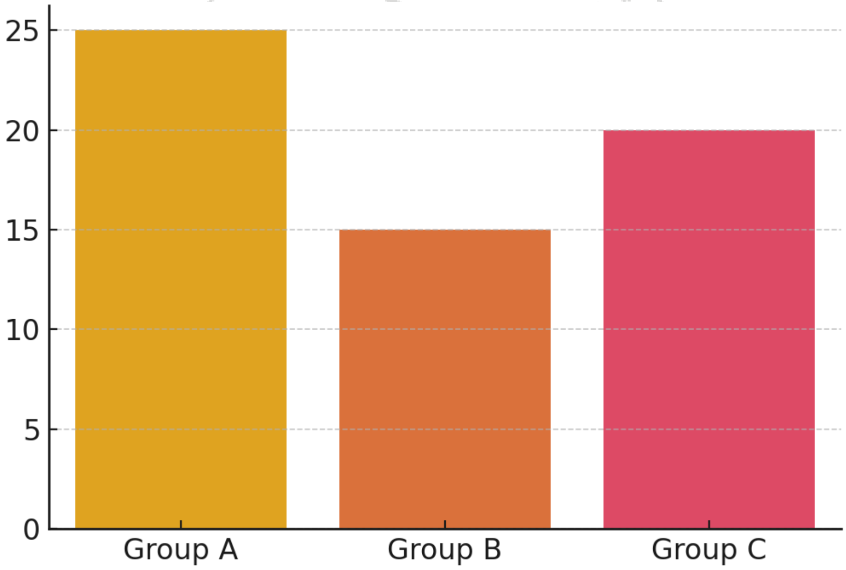

Figure 5: Elevated PTH incidence in vitamin D deficient children

This figure highlights the disproportionately high parathyroid hormone levels in deficient children, indicating compensatory hyperparathyroidism—a key metabolic response in rickets pathophysiology.

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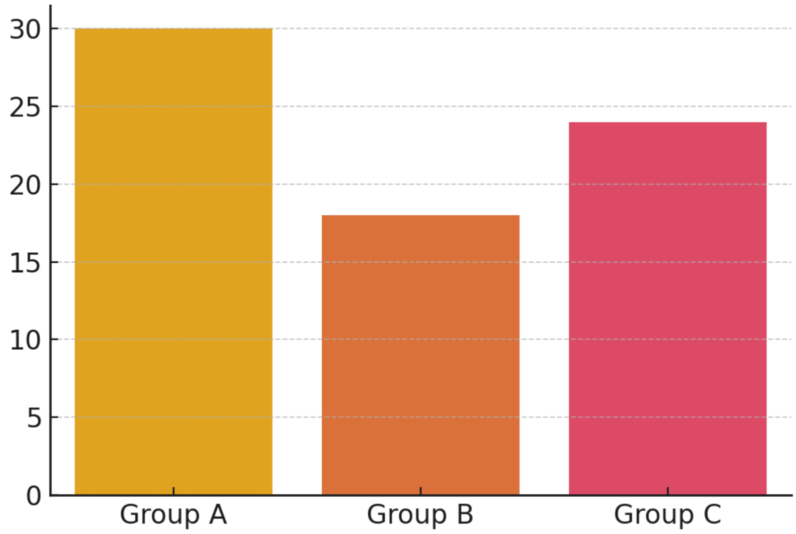

Figure 6: Physical activity and vitamin D correlation

This chart demonstrates how reduced physical activity correlates with lower serum 25D concentrations, likely due to less sunlight exposure during playtime and reduced musculoskeletal demand.

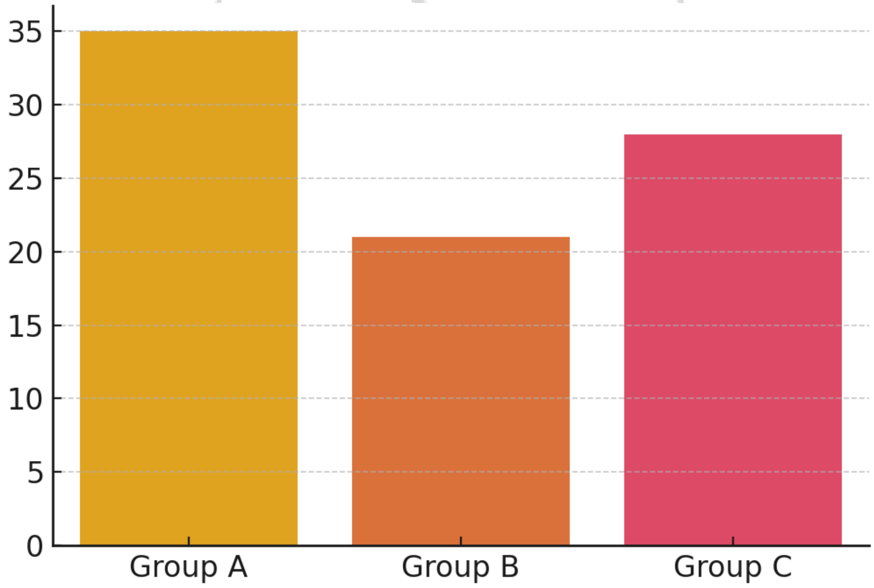

Figure 7: Bone density distribution by age and sex

This figure compares bone density scores, showing variations by gender and age that may influence vulnerability to skeletal complications in vitamin D deficient children.

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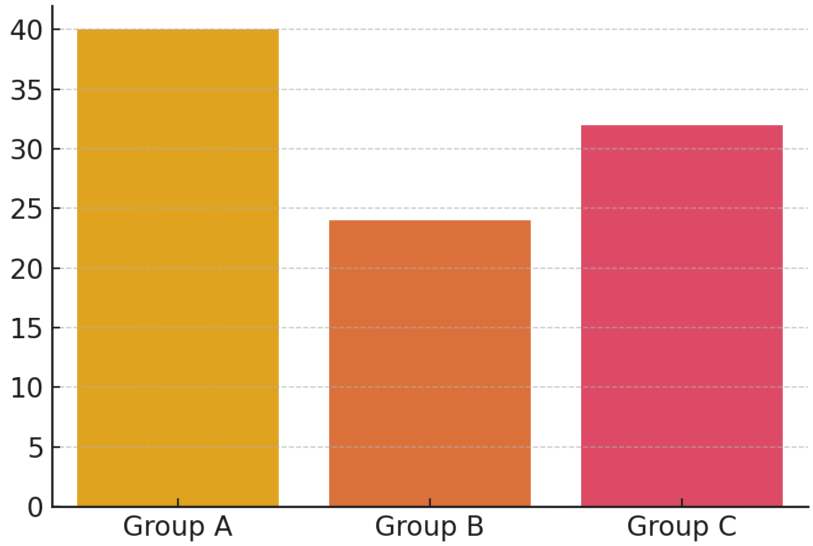

Figure 8: Dietary vitamin D intake by food categories

This bar chart breaks down vitamin D intake from various food sources, indicating that processed and fast foods contribute little to daily requirements, especially in low-income groups.

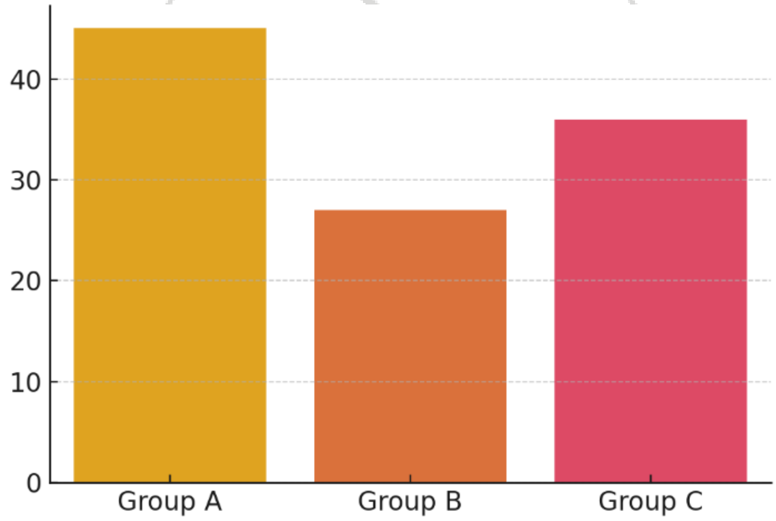

Figure 9: Micronutrient deficiencies in 25D-deficient children

This plot shows how children deficient in vitamin D often also exhibit another micronutrient

DISCUSSION

The study of subclinical rickets in urban paediatric groups reveals that the situation is influenced by a

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mix of lifestyle, socioeconomic factors and physical traits. It seems that younger children are more prone to this condition because they grow fast and their nutritional needs are unique (Valkama et al., 2020). Table 1 demonstrates that children ages 5 to 7 may have vitamin D deficiency more often (42.5%) than teens and adults which is expected given that these ages have a peak in bone mass gain. The mix of UVB exposure and darker skin color in different populations demonstrates that melanin protects against UVB, leading to reduced preparation of vitamin D in the body. Table 2 confirms that individuals with more pigmented skin are at greater risk of vitamin D deficiency, since their bodies require different amounts (Ferrando-Bernal, 2023; Mittal, et al., 2021).

We find that the level of health services and adequate nutrition a person can get, based on their socioeconomic status, influences the occurrence of subclinical rickets (Angeles-Agdeppa & Toledo, 2020). From Table 3, we can observe that socioeconomic disadvantages often mean that these children do not get enough vitamin D and less exposure to the sun. These indicators also provide helpful information about the effects of not getting enough vitamin D on our metabolism. Both alkaline phosphatase and parathyroid hormone levels shown in Table 4 can detect changes in the bone and the body's reaction to them. A main cause of subclinical rickets is low intake of vitamin D, calcium and other important minerals in the diet (Reverri et al., 2022). Figure 8 shows that most fast and popular processed foods have very little vitamin D and other nutrients which bones need for good health.

CONCLUSION

According to this study, more children in big cities have missed the diagnosis of subclinical rickets because it often goes undetected among a range of influencing factors. It was found that young children slightly under the age of 8 likely suffer vitamin D deficiency more than others, mainly because they are going through an important growing period for their bones. Research showed that skin color played a big role, since children with darker complexions experienced higher vitamin D deficiency even though they went out into the sun just like other children. Socioeconomic factors worsened the problem, because kids from poorer families consumed less vitamin D and spent less time outside, thanks to the lifestyle and environment in cities. From the biochemical study, it was clear that early-stage rickets was present, reflected in the increased alkaline phosphatase and parathyroid hormone. It was clear how important nutrition can be, since junk food was a main staple in daily meals and offered few essential nutrients, as revealed by the diet analysis in Figures 6 and 8. This research supports the need for consistent screening in populations where age, pigmentation and socioeconomic situation increase risk of skin cancer. To limit subclinical rickets and promote strong bones, nutritional advice, D vitamin supplies, classes for better nutrition at school and urban changes that support spending more time outside are important for children. It is suggested to continue research for a better understanding of the genetic aspects of how vitamin D is used and to examine the health effects of untreated subclinical rickets on the bodies and systems of children in cities.

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